3.5 GEOLOGY, SOILS, AND PALEONTOLOGICAL RESOURCES

3.5.1 INTRODUCTION

This section identifies the environmental setting and evaluates the potential impacts related to geology, soils, and paleontological resources, as well as seismic conditions, in the Phase 1 SERP coverage area.

3.5.2 REGULATORY SETTING

FEDERAL PLAN, POLICIES, REGULATIONS, AND LAWS

The SERP entails work along levees that are within the SRFCP area. Levee design and construction must be performed in accordance with USACE's *Engineering Design and Construction of Levees* (USACE 2000), which are the primary federal standards applicable to levee improvements. This document contains the basic principles used for the design and construction of federal levees. In general, it provides requirements for analysis of issues such as underseepage, through-seepage, slope stability, and settlement, and specifies design of features including embankments, slope protection, and borrow sites. In addition, this document provides an outline of geologic and subsurface investigations for project feasibility that covers both technical studies and field surveys. Evaluations include geophysical exploration for the top of bedrock, faults, suspected voids, material boundaries, subsurface conduits, groundwater fluctuations, soils permeability, and foundation strengths.

STATE PLANS, POLICIES, REGULATIONS, AND LAWS

Because the SERP would involve work on levees, the Central Valley Flood Protection Board's (CVFPB's) standards are the primary state standards applicable to the proposed levee maintenance and repairs; these are stated in Title 23, Division 1 of the California Code of Regulations. These requirements pertain to the aspects of structure design and construction that could affect flood management projects. These requirements cover issues such as use of borrow material; pipelines; bicycle trails; vegetation; dredged, spoiled, and waste materials; and other encroachments within the flood management limit. In addition, this article supplements the USACE manual, *Engineering Design and Construction of Levees* (described above), requires submission of documentation to the CVFPB (e.g., geotechnical studies, seismic surveys, settlement analysis), and provides specifications related to construction material, design of levees, and utility structure requirement. DWR maintenance yards that inspect and repair levees within the SRFCP conduct those operations in accordance with CVFPB and federal requirements.

Regional and Local Plans, Policies, Regulations, and Ordinances

The work proposed under Phase 1 of the SERP occurs in six California counties (i.e., Sacramento, Yolo, Solano, Sutter, Colusa, and Butte). Each county has its own policies under county general plans and local ordinances. Within the counties, local municipalities also influence various aspects of land use through their own general plans and local codes.

3.5.3 Environmental Setting

Topography

Topography of individual erosion sites would consist of gentle terrain along the channels and steeper sloping terrain along embankments and levees. The proposed repairs would occur along existing levees and associated waterside slopes within the levee prism, which are sloped from the levee crown toward the surface of the water. The slopes where improvements would occur range in steepness from 3:1 to 1:1.

Geology

The Phase 1 SERP erosion sites would all be located within the Sacramento Valley, which is 30–45 miles wide in the southern to central parts, but narrows to about 5 miles near Red Bluff. The elevation of the Sacramento Valley decreases almost imperceptibly from 300 feet at its northern end to near sea level in the Sacramento–San Joaquin River Delta (Delta). The Sacramento Valley and the San Joaquin Valley together make up the Central Valley Geomorphic Province. This province consists of a sediment-filled trough that extends over 400 miles from north to south and separates the primarily granitic rock of the Sierra Nevada to the east from the primarily Franciscan Formation rock of the California Coastal Ranges to the west.

The central portion of the Sacramento Valley consists mainly of Holocene-age (i.e., 11,000 years Before Present [BP] and younger) basin and alluvial sediments that were deposited by the Sacramento River and its two major local tributaries—Putah and Cache Creeks. In the southern area of the Sacramento Valley, these deposits grade into the peat-rich muds of the Delta. East of the Sacramento River, large areas of the Modesto and Riverbank Formations overlie older alluvial fan deposits of the Turlock Lake, Laguna, and Mehrten Formations. Moving north, the eastern side of the Sacramento Valley opposite to and north of the Sutter Buttes is covered by Holocene-age alluvial deposits from the Feather River and smaller streams of the western Sierra Nevada. Deposits of the Riverbank Formation are also found in this area (Helley and Harwood 1985).

SOILS

The soils of the Sacramento Valley vary widely as a result of differences in geomorphologic processes, climate, parent material, biologic activity, topography, and time. Under the SERP, DWR would conduct annual maintenance surveys each spring to identify small erosion sites within the Phase 1 SERP coverage area that require repairs to maintain the integrity of the flood management system. DWR would conduct a baseline assessment at each site in accordance with Section B of the SERP Manual (see Appendix B) to evaluate and document the erosion damage. Because specific sites would be selected on a case-by-case basis by DWR staff members, this analysis does not attempt to evaluate the erosion potential or other soil properties along every water body shown in Exhibit 2-1 “Phase 1 Coverage Area for the Small Erosion Repair Program.” Therefore, the list of soil types shown in Table 3.5-1 is not intended to be all inclusive; rather, it is intended to disclose to agencies and members of the public the types of soils and their properties that may generally be encountered at erosion sites where work may occur under the SERP.

Erosion

Soil erosion rates at the SERP sites vary depending on location, soil characteristics, climate, slope, type of vegetation and levee construction materials, amount of wind and wave activity, and runoff from precipitation events. Severe soil erosion can damage the levee system; such damage can ultimately lead to structural failure of the levee. Secondary effects of erosion occur when the eroded soil particles are carried downstream and later deposited as sediment, which can adversely affect aquatic species and their habitat. Soils along various portions of the levees within the SRFCP area are subject to erosion.

Subsidence

Subsidence of the land surface can be induced by both natural and human phenomena. Natural phenomena that can cause subsidence can result from tectonic deformations and seismically induced settlements; consolidation, hydrocompaction, or rapid sedimentation; oxidation or dewatering of organic-rich soils; and subsurface cavities. Subsidence related to human activity can result from withdrawal of subsurface fluids or sediment. Pumping of water for residential, commercial, and agricultural uses from subsurface water tables causes more than 80% of the identified subsidence in the United States (Galloway et al. 1999). Lateral spreading is the horizontal movement or spreading of soil toward an open face, such as a streambank, the open side of fill embankments, or the sides of levees. The potential for failure from subsidence and lateral spreading is highest in areas where the groundwater table is high, where relatively soft and recent alluvial deposits exist, and where creek banks are relatively high.

Table 3.5-1 General Soil Types and Properties in the Phase 1 SERP Coverage Area				
Soil Series Name	**Description**	**Shrink/ Swell Potential**	**Permeability**	**Drainage**
Sacramento County				
Dierssen	Sandy or clay loam	Moderate	Moderately high	Somewhat poorly drained
Egbert	Clay	High	Moderately low	Poorly drained
Lang	Sandy Loam	Low	High	Moderately well drained
Laugenour	Loam	Low	High	Poorly drained
Sailboat	Silt loam	Low	Moderately high	Somewhat poorly drained
San Joaquin	Sand or silt loam	Low	Moderately high	Moderately well drained
Scribner	Clay loam	Moderate	Moderately high	Poorly drained
Valpac	Loam	Moderate	Moderately high	Somewhat poorly drained
Colusa County				
Capay	Clay loam	High	Very slow	Moderately well drained
Corbiere	Silt loam	High	Slow	Somewhat poorly drained
Grandbend	Loam	Moderate	Moderately slow	Somewhat poorly drained
Moonbend	Silt loam	Moderate	Moderately high	Moderately well drained
Scribner	Silt loam	Low	Moderately low	Poorly drained
Tujunga	Loam	Low	Moderately high	Excessively drained
Vina	Loam	Low	Moderately low	Well drained
Willows	Silty clay	High	Moderately low	Poorly drained
Solano County				
Reiff	Sandy loam	Low	High	Well drained
Yolo	Loam	Low	Moderately high	Well drained

Table 3.5-1
General Soil Types and Properties in the Phase 1 SERP Coverage Area

Soil Series Name	Description	Shrink/ Swell Potential	Permeability	Drainage
Butte County				
Almendra	Loam	Low	Moderately high	Well drained
Blavo	Silt loam	Very high	Moderately high	Poorly drained
Clear Lake	Clay	Very high	Moderately high	Poorly drained
Conejo	Sandy loam	Low	High	Well drained
Esquon	Silty clay loam	High	Moderately high	Poorly drained
Gianella	Sandy loam	Low	High	Moderately well drained
Liveoak	Sandy loam	Low	High	Moderately well drained
Neerdobe	Silt loam	Low	High	Poorly drained
Redtough	Loam	Low	Moderately high	Somewhat poorly drained
Thompson Flat	Loam	Low	Moderately high	Moderately well drained
Yolo County				
Brentwood	Silty clay loam	High	Moderately high	Well drained
Hillgate	Loam	Low to moderate	Moderately high	Well drained
Maria	Silt loam	Moderate	Moderately high	Poorly drained
Marvin	Silty clay loam	Moderate	Moderately high	Somewhat poorly drained
Merritt	Silty clay loam	Moderate	Moderately high	Poorly drained
Pescadero	Silty clay	High	Moderately low	Poorly drained
Rincon	Silty clay loam	Moderate	Moderately high	Well drained
Riz	Loam	Moderate	Moderately high	Poorly drained
Sacramento	Silty clay loam or clay	High	Moderately low to moderately high	Poorly drained
Sycamore	Silt loam or clay loam	Low to moderate	Moderately high	Somewhat poorly drained

Table 3.5-1 General Soil Types and Properties in the Phase 1 SERP Coverage Area				
Soil Series Name	Description	Shrink/ Swell Potential	Permeability	Drainage
Sutter County				
Columbia	Sandy loam	Low	High	Somewhat poorly drained
Gridley	Clay loam	Moderate	Moderately high	Somewhat poorly drained
Holillipah	Loamy sand or sandy loam	Low	High	Somewhat excessively drained
Marcum	Clay loam	Moderate	Moderately high	Moderately well drained
Nueva	Loam	Low	Moderately high	Somewhat poorly drained
Oswald	Clay	High	Moderately low	Poorly drained
Shanghai	Sandy loam or silt loam	Moderate	Moderately high	Somewhat poorly drained
Subaco	Clay	High	Moderately low	Poorly drained
Tisdal	Clay loam	Moderate	Moderately high	Well drained
Yuvas	Loam	Moderate	Moderately high	Moderately well drained

Notes:
[1] Based on percentage of linear extensibility.
[2] Based on standard U.S. Department of Agriculture saturated hydraulic conductivity (Ksat) class limits; Ksat refers to the ease with which pores in a saturated soil transmit water.
Source: NRCS 2009

SEISMICITY

Potential seismic hazards resulting from a nearby moderate to major earthquake can generally be classified as primary and secondary. The primary effect is fault ground rupture, also called surface faulting. Common secondary seismic hazards include ground shaking, liquefaction, and subsidence. Each of these potential hazards is discussed below.

Fault Ground Rupture

Surface rupture is an actual cracking or breaking of the ground along a fault during an earthquake. Structures built over an active fault can be torn apart if the ground ruptures. Surface ground rupture along faults is generally limited to a linear zone a few yards wide.

The Alquist-Priolo Earthquake Fault Zoning Act was created to prohibit the location of structures designed for human occupancy across the traces of active faults, thereby reducing the loss of life and property from an earthquake. There are no Alquist-Priolo Earthquake Fault Zones within the Phase 1 SERP coverage area (CGS 2010, Hart and Bryant 1999).

Seismic Ground Shaking

The Foothills Fault system is located approximately 30 miles east of the Phase 1 SERP coverage area; however, Jennings (1994) does not indicate that fault activity has occurred within the last 11,000 years, and the slip rate of the Foothills Fault system is extremely low (0.05 millimeters per year), which is well below the planning threshold for major earthquakes (USGS 2000). The northern segment of the Cleveland Hills Fault, located near Lake Oroville, is approximately 10 miles northeast of the northernmost portion of the Feather River where the Phase 1 SERP work could occur. However, research conducted by DWR indicates that the magnitude 5.7 earthquake that occurred on August 1, 1975, along the Cleveland Hills Fault mostly likely resulted from reservoir-induced stress (DWR 1989). The Dunnigan Hills Fault, approximately 5 miles north of the Phase 1 SERP coverage area, may have been the source of an earthquake in 1892 that caused damage in Vacaville and Winters. However, with the exception of these two known sources of seismic activity during historic time (i.e., the last 200 years), the Sacramento Valley has generally not been seismically active during the Holocene. Faults with known or estimated activity during the Holocene epoch are generally located in the San Francisco Bay Area to the west, as shown in Table 3.5-2. In addition, Table 3.5-2 identifies the faults' approximate distance from the Phase 1 SERP coverage area, the fault type, and the maximum moment magnitude of the fault.

Liquefaction

Soil liquefaction occurs when ground shaking from an earthquake causes a sediment layer saturated with groundwater to lose strength and take on the characteristics of a fluid. Primary factors used in determining the liquefaction potential are soil type, the level and duration of seismic ground motions, the distance from an active seismic source, and the depth to groundwater. Loose sands and peat deposits are generally the most susceptible to liquefaction. Age is also a factor in the potential of soils to liquefy, with the younger (less than 11,000 years old) Holocene deposits being the most sensitive to liquefaction.

Sediments used in construction of the levees vary depending on the location. In some locations, they consist of loosely compacted Holocene-age fill material. In others, levee materials consist of older Pleistocene-age fill material from borrow sites that has been engineered, designed, and compacted specifically to withstand potential damage from liquefaction.

PALEONTOLOGY

The Phase 1 SERP coverage area is depicted in Exhibit 2-1, in Chapter 2, "Project Description." Because the site-specific locations of future repairs are unknown, exactly which geologic formations would be affected by earth-moving activities is not possible to determine. For this paleontological analysis, published geologic maps at a scale of 1:250,000 were

Table 3.5-2
Faults with Evidence of Activity During Holocene Time in the SERP Region

Fault Name	Approximate Distance from Nearest SERP Levee Site (miles)	Fault Type[1]	Maximum Moment Magnitude[2]	Slip Rate (mm/yr)	Regional Location
Dunnigan Hills	5	N/A	N/A	N/A	Western Sacramento Valley
Cleveland Hills/Swain Ravine	15	N/A	6.5	N/A	Sierra Nevada foothills
Great Valley Fault Zone Segment 4	15	B	6.6	1.5	Margin between Sacramento Valley and Coast Range
Hunting Creek-Berryessa	30	B	7.1	3.0	Coast Range
Green Valley	40	B	6.2	5.0	Coast Range
Greenville Fault Zone (includes Clayton and Marsh Creek sections)	50	B	6.6	2.0	Coast Range

Notes:
N/A = not available or not known; mm/yr = millimeters per year
[1] Faults with an "A" classification are capable of producing large magnitude (M) events (M greater than 7.0), have a high rate of seismic activity (e.g., slip rates greater than 5 millimeters per year), and have well-constrained paleoseismic data (e.g., evidence of displacement within the last 700,000 years). Class "B" faults are those that lack paleoseismic data necessary to constrain the recurrence intervals of large-scale events. Faults with a "B" classification are capable of producing an event of M 6.5 or greater.
[2] The moment magnitude scale is used by seismologists to compare the energy released by earthquakes. Unlike other magnitude scales, it does not saturate at the upper end, meaning that there is no particular value beyond which all earthquakes have about the same magnitude, which makes this scale a particularly valuable tool for assessing large earthquakes.
Sources: Cao et al. 2003, Jennings 1994, Petersen et al. 1996, data compiled by AECOM in 2009

reviewed to determine which geologic formations underlie the existing levees and determine the potential geologic formations where Phase 1 SERP work may occur. Table 3.5-3 presents the project reach, the formation name and age, and the determination of paleontological sensitivity. A detailed description of each formation follows.

Table 3.5-3
Paleontological Sensitivity of Rock Formations in the Phase 1 SERP Coverage Area

Project Reach[1]	Rock Formation Name and Age	Paleontological Sensitivity
Butte Creek	Basin Deposits/Holocene	Low
	Modesto/Pleistocene	High
Cherokee Canal	Basin Deposits/Holocene	Low
Feather River from River Mile 31 to Western Canal Left Bank	Natural Levee and Channel Deposits/ Holocene	Low
	Modesto/Pleistocene	High
	Riverbank/Pleistocene	High
Sacramento River west of Cherokee Canal, south below Colusa	Natural Levee and Channel Deposits/ Holocene	Low
Colusa Trough	Basin Deposits/Holocene	Low
East/West Levee above Wadsworth Canal	Basin Deposits/Holocene	Low
	Modesto/Pleistocene	High
Wadsworth Canal, Sutter Bypass, Nelson Slough	Natural Levee and Channel Deposits/ Holocene	Low
	Basin Deposits/Holocene	Low
	Riverbank/Pleistocene	High
Cache Creek, Tule Canal	Natural Levee and Channel Deposits/ Holocene	Low
	Basin Deposits/Holocene	Low
Willow Slough Bypass	Basin Deposits/Holocene	Low
	Modesto-Riverbank mix/Pleistocene	High
South Fork Putah Creek	Natural Levee and Channel Deposits/ Holocene	Low
	Basin Deposits/Holocene	Low
	Modesto/Pleistocene	High
Sacramento Bypass and south along Sacramento River	Natural Levee and Channel Deposits/ Holocene	Low
	Basin Deposits/Holocene	Low
	Riverbank/Pleistocene	High

Note:
[1] Based on estimated Phase 1 SERP coverage areas shown in Exhibit 2-1.
Sources: Jennings and Strand 1960, Wagner et al. 1987, Saucedo and Wagner 1992

Description of Geologic Formations

Natural Levee and Channel Deposits

This geologic formation consists of deposits of active stream channels and their natural levees, as well as adjacent broad alluvial fans. These deposits are of Holocene age (i.e., 11,000 year BP and younger).

Basin Deposits

This geologic formation consists of fine grained deposits of silt and clay in flood basins between modern watercourses (locally, this includes marsh deposits). These deposits also are of Holocene age.

Modesto Formation

The Modesto Formation forms ancient alluvial terraces and some fans and channel ridges of major rivers, and can be divided into upper and lower members. It generally consists of tan and light-gray gravely sand, silt, and clay. Helley and Harwood (1985, citing Marchand and Allwardt 1981) suggest an age range of 12,000 to 26,000 years BP for the upper member, and 29,000 to 42,400 years BP for the lower member (i.e., Pleisotcene in age). The Modesto Formation is underlain at depth by the Riverbank Formation, the Turlock Lake Formation, and the Laguna Formation (among others).

Riverbank Formation

Sediments of the Riverbank Formation consist of weathered reddish gravel, sand, and silt that form alluvial terraces and fans. In the Sacramento Valley, this formation contains more mafic igneous rock fragments than the San Joaquin Valley, and thus tends towards stronger soil profile developments that are more easily distinguishable from the Modesto Formation.

The Riverbank Formation is Pleistocene in age but is considerably older than the Modesto Formation; estimates place it between 130,000 and 450,000 years BP (Helley and Harwood 1985 citing Marchand and Allwardt 1981). Similar to the Modesto Formation, the Riverbank Formation also forms alluvial fans and terraces on major rivers; however, Riverbank fans and terraces are higher in elevation and generally have a more striking topography than those formed by the Modesto.

Paleontological Sensitivity

A paleontologically important rock unit is one that: 1) has a high potential paleontological productivity rating, and 2) is known to have produced unique, scientifically important fossils. The potential paleontological sensitivity rating of a rock unit exposed at a project site refers to the abundance/densities of fossil specimens and/or previously recorded fossil sites in exposures of the unit in and near the project site. Exposures of a specific rock unit at a project site are most likely to yield fossil remains representing particular species, in quantities or densities similar to those previously recorded from the unit in and near the project site.

Natural Levee and Channel Deposits/Basin Deposits

By definition, to be considered a fossil, an object must be older than 11,000 years BP. Because the Natural Levee and Channel Deposits and the Basin Deposits are of Holocene age (i.e., less than 11,000 years BP), they would not contain unique paleontological resources.

Modesto and Riverbank Formations

Jefferson (1991a, 1991b) compiled a database of California Late Pleistocene vertebrate fossils from published records, technical reports, unpublished manuscripts, information from colleagues, and inspection of museum paleontological collections at more than 40 public and private institutions. He listed numerous sites throughout the Sacramento and San Joaquin Valleys yielding Rancholabrean vertebrate fossils that could be referable to the Modesto or Riverbank Formations.

A search of the University of California, Berkeley Museum of Paleontology database (UCMP 2012) indicates that remains of land mammals have been found throughout northern California, at various localities in alluvial deposits that are referable to the Modesto and Riverbank Formations, including Yuba City, Sutter, Lincoln, Woodland, Davis, Sacramento, and Elk Grove, as well as Stockton, Lathrop, Tracy, Modesto, and numerous other locations in the Central Valley. In the Sacramento Valley, these localities have yielded fossil specimens of rodents, snakes, horses, antelope, bison, coyote, camel, Harlan's ground sloth, mammoth, and saber-toothed tiger.

The Modesto and Riverbank Formations are considered to be of high paleontological sensitivity because of the thousands of fossil specimens recovered throughout the Sacramento and San Joaquin Valleys from them.

3.5.4 ENVIRONMENTAL IMPACTS AND MITIGATION MEASURES

THRESHOLDS OF SIGNIFICANCE

Based on Appendix G of the CEQA Guidelines, the SERP would result in a significant impact on geology and soils if it would:

- expose people, property, or structures to potential substantial adverse impacts, including the risk of loss, injury, or death involving:

- rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map issued by the State Geologist for the area or based on other substantial evidence of a known fault;
- landslides;
- cause substantial soil erosion or the loss of topsoil;

- be located on a geologic unit or soil that is unstable, or that would become unstable as a result of the project, and potentially result in on- or off-site landslide, lateral spreading, subsidence, liquefaction, or collapse;
- be located on expansive soil, as defined in Table 18-1-B of the Uniform Building Code (1994), creating substantial risks to life or property; or
- have soils incapable of adequately supporting the use of septic tanks or alternative waste water disposal systems.

Based on Appendix G of the CEQA Guidelines, a project would have a significant impact on paleontological resources if it would directly or indirectly destroy a unique paleontological resource or site. For the purposes of this DEIR, a unique resource or site is one that is considered significant under the following professional paleontological standards.

An individual vertebrate fossil specimen may be considered unique or significant if it is identifiable and well preserved, and it meets one of the following criteria:

- a type specimen (i.e., the individual from which a species or subspecies has been described);
- a member of a rare species;
- a species that is part of a diverse assemblage (i.e., a site where more than one fossil has been discovered) wherein other species are also identifiable, and important information regarding life history of individuals can be drawn;
- a skeletal element different from, or a specimen more complete than, those now available for its species; or
- a complete specimen (i.e., all or substantially all of the entire skeleton is present).

The value or importance of different fossil groups varies, depending on the age and depositional environment of the rock unit that contains the fossils, their rarity, the extent to which they have already been identified and documented, and the ability to recover similar materials under more controlled conditions (such as for a research project). Marine invertebrates generally are common; the fossil record is well developed and well documented, and they generally would not be considered a unique paleontological resource. Identifiable vertebrate marine and terrestrial fossils generally are considered scientifically important because they are relatively rare.

Analysis Methodology

Evaluation of potential geology and soils impacts for the project relied on U.S. Natural Resources Conservation Service soil survey data ("Web Soil Survey") and published geologic literature and maps. The information obtained from these sources was reviewed and summarized to present the environmental setting and to identify potential environmental impacts, based on the thresholds of significance presented in this section. Impacts associated with geology and soils that could result from construction and operational activities were evaluated qualitatively based on expected construction practices and materials, locations, and duration of construction and related activities. Proposed engineering cross-sections of work to be performed at the erosion sites, prepared by DWR, were also used to evaluate potential impacts. These conceptual exhibits are provided in Section C, "Project Design Templates and Construction Details," of the SERP Manual in Appendix B (of this DEIR).

In its standard guidelines for assessing and mitigating adverse impacts on paleontological resources, the Society of Vertebrate Paleontology (1995:22–27) has established three categories of sensitivity for paleontological resources: high, low, and undetermined. Areas where fossils previously have been found are considered to have a high sensitivity and a high potential to produce fossils. Areas that are not sedimentary in origin and that have not been known to produce fossils in the past typically are considered to have low sensitivity. Areas that have not had any previous paleontological resource surveys or fossil finds are considered to be of undetermined sensitivity until surveys and mapping are performed to determine their sensitivity. After reconnaissance surveys, observation of exposed cuts, and possibly subsurface testing, a qualified paleontologist can determine whether an area should be categorized as having high or low sensitivity. In keeping with the significance criteria of the Society of Vertebrate Paleontology (1995:22–27), all vertebrate fossils generally are categorized as being of potentially significant scientific value.

IMPACTS NOT DISCUSSED FURTHER IN THIS DEIR

The SERP sites would not be located in areas of steep terrain and therefore would not subject people or structures to hazards from landslides. Additionally, the SERP would not involve wastewater treatment. Therefore, the risks to people or structures caused by landslides and the soil suitability for use with septic tanks are not discussed further in this DEIR.

IMPACT ANALYSIS

IMPACT 3.5-1 ***Risks to People or Structures Caused by Surface Fault Rupture.*** *The Phase 1 SERP coverage area is not located within or adjacent to an Alquist-Priolo Earthquake Fault Zone or any known active fault. Therefore, this impact would be* ***less than significant****.*

The Phase 1 SERP coverage area is not located within or adjacent to an Alquist-Priolo Earthquake Fault Zone, nor is the coverage area underlain by or located adjacent to any other known active faults. The SERP work that would occur along the northern portion of the Feather River would be located approximately 10 miles from the nearest Alquist-Priolo Earthquake Fault Zone/known active fault (the Cleveland Hill/Swain Ravine Fault). Furthermore, the SERP would not include the construction of any pipelines, permanent roadways, bridges, or structures intended for human habitation. Because damage from surface fault rupture is generally limited to a linear zone a few yards wide, the potential for surface fault rupture to cause damage to the proposed erosion repairs would be less than significant.

No mitigation is required.

IMPACT 3.5-2 ***Possible Risks to People and Structures Caused by Strong Seismic Ground Shaking.*** *The Phase 1 SERP coverage area is located in an area of generally low seismic activity. Therefore, this impact would be* ***less than significant****.*

The northern segment of the Cleveland Hills/Swain Ravine Fault, located near Lake Oroville, is approximately 10 miles northeast of the northernmost portion of the Feather River where SERP work could occur. However, research conducted by DWR indicates that the magnitude 5.7 earthquake that occurred on August 1, 1975, along the Cleveland Hills Fault, mostly likely resulted from reservoir-induced stress (DWR 1989). The Dunnigan Hills Fault, approximately 5 miles north of the Phase 1 SERP coverage area along Cache Creek in the southwestern portion of the Sacramento Valley, has been classified by Jennings (1994) as active and may have been responsible for a damaging earthquake in Vacaville and Winters in 1892. Aside from these two faults where earthquakes occurred in 1975 and 1892, the Sacramento Valley has historically experienced very low levels of seismic activity. Faults with known or estimated activity during the last 11,000 years are generally located in the San Francisco Bay Area within the Coast Ranges geomorphic province. The SERP projects would be small in size, would occur in the levee surface soils (therefore the core structural integrity of the levees would not be affected), and are intended to achieve an overall strengthening of the levees by addressing the effects of ongoing erosion. Small levee repair projects are considered maintenance projects rather than levee modification projects; thus, the repairs do not entail upgrades to seismic design or geometry issues. Furthermore, the SERP would not include the construction of any pipelines, permanent roadways, bridges, or structures intended for human habitation. All erosion repairs would be designed using the approved SERP templates supported by the results of geotechnical engineering evaluation. Therefore, because the SERP sites would not likely experience strong seismic ground shaking, and erosion repairs would meet or exceed applicable design standards, this impact would be less than significant.

No mitigation is required.

IMPACT 3.5-3 ***Geologic Hazards from Liquefaction, Unstable Soils, and Shrink-Swell Potential.*** *The Phase 1 SERP coverage area is located within an area that could be subject to geologic hazards from liquefaction, unstable soils, and shrink-swell potential. However, the erosion repairs would be engineered to withstand these hazards, and therefore this impact would be* ***less than significant****.*

Levees are subject to two types of hazards related to liquefaction: (1) as induced by seismic activity, and (2) as induced by construction activity in saturated soils. In the latter case, when loose, unconsolidated silty soils become saturated with water, the weight of construction equipment on those saturated soils can cause the sediments to liquefy and sink. Liquefaction of the levees could result in a direct hazard to construction workers and indirect hazards to residents in the area from flooding and to aquatic habitat from increased sediment transport in stream channels. Construction on portions of the levees that consist of unstable soils could result in the same direct and indirect hazards.

Sediments that were used to construct the existing levees vary depending on the location. In many locations, particularly where more recent levee repair work has occurred, levee materials consist of older Pleistocene-age fill material from borrow sites that have been engineered, designed, and compacted specifically to withstand potential damage from liquefaction. However, in locations where the levees are older, levee fill materials consist of loosely compacted and/or silty or clayey Holocene-age fill material that could be unstable, subject to liquefaction, or have a high shrink-swell potential.

As shown in the engineering design templates attached to this DEIR as Appendix B, the erosion repairs would be specifically engineered to account for stability factors and safety coefficients, including liquefaction, unstable soils, and shrink-swell potential. As further stated by DWR engineers (McGrath, pers. comm., 2009; Eckman, pers. comm., 2009), on-site soil investigations would be made by a qualified engineer at each erosion site and repairs would be designed to appropriately withstand these hazards. Therefore, this impact would be less than significant.

No mitigation is required.

IMPACT 3.5-4 ***Potential for Substantial Erosion.*** *The SERP has been specifically designed to reduce erosion. Therefore, this impact would be **beneficial**.*

The purpose of implementing the SERP is to expeditiously repair existing erosion sites to maintain the SRFCP integrity and prevent further erosion from occurring at those sites to reduce the flood risk and maintain riparian and nearshore aquatic habitat. DWR staff members would select specific sites for erosion repair on a case-by-case basis and would conduct a baseline assessment at each site in accordance with Section B of the SERP Manual (Appendix B) to evaluate and document the erosion damage. The erosion repair templates have been designed to be self-mitigating through incorporation of bioengineering erosion control methods. Erosion repair at each site would involve one of the following methods:

- bank fill rock slopes with live pole planting,
- willow wattle with rock toe,
- branch layering,
- rock toe with live pole planting,
- soil and rock fill at the base of a fallen tree,
- bank fill rock slope with native grass planting, or
- bank fill rock slope with emergent vegetation planting.

Engineering design schematics for each of these erosion repair options are shown in Templates 1–7, in Section C of the SERP Manual (Appendix B). Maximum slopes associated with the repairs would range from 3:1 to 1:1. Each of the erosion repair options would involve placing a varying amount and composition of rock riprap and/or soil or vegetation. The project engineer would use a DWR-approved rock sizing chart as a guide to determine appropriate rock size and weight based on local scour velocities, with adjustments for bank angle, bend hydraulics, stability factors, and safety coefficients. Appropriate locations for each type of erosion repair would be determined on a case-by-case basis by the project engineer.

DWR would also conduct multiyear monitoring of each SERP repair site within the Phase 1 coverage area and would submit annual monitoring reports to the appropriate regulatory agencies to track and evaluate the success of the SERP.

Because the SERP would implement repair mechanisms to address erosion, this impact would be beneficial.

No mitigation is required.

IMPACT 3.5-5 ***Potential Damage to Unknown, Unique Paleontological Resources during Earthmoving Activities.*** *Portions of the Phase 1 SERP coverage area may be located within areas having high potential for paleontological resources. However, native soils are unlikely to be disturbed, and therefore this impact would be* ***less than significant****.*

As described in Sections B and C of the SERP Manual, potential SERP projects would be categorized into two tiers, based on the size of the project disturbance area, and then DWR would identify the appropriate preapproved SERP design template to be applied. The Phase 1 SERP would have a maximum of 15 projects per year that could include any combination of the following:

> Tier 1: The footprint of new bank protection materials, including any additional vegetated area that would be disturbed by equipment during construction, would be 0.1 acre or less with a maximum linear foot limit of 264 feet.

> Tier 2: The footprint of new bank protection materials, including any additional vegetated area that would be disturbed by equipment during construction, would be 0.5 acre or less with a maximum linear foot limit of 1,000 feet.

Thus, the total acreage disturbed during the Phase 1 SERP could range from 1.5 to 7.5 acres per year. Erosion repair at each site would involve one of the following methods:

- bank fill rock slopes with live pole planting,
- willow wattle with rock toe,
- branch layering,
- rock toe with live pole planting,
- soil and rock fill at the base of a fallen tree,
- bank fill rock slope with native grass planting, or
- bank fill rock slope with emergent vegetation planting.

The Modesto and Riverbank Formations are of high paleontological sensitivity because of the large number of Pleistocene-age fossils that have been recovered from those formations throughout the Central Valley. Although these formations may be located on the landside of and/or underneath existing levees, they are present only in certain locations rather than throughout the length of the levees. Based on the types of repair methods and the fact that SERP projects would take place primarily within existing levees, very little excavation is likely to occur within native soils (if any). If earth-moving activities were to occur within either of these rock formations (depending on a specific project location), considering the extremely small size of the projects (1.5 to 7.5 acres total per year) and the low probability that any construction project would encounter unique paleontological resources, this impact would be less than significant.

No mitigation is required.

3.5.5 RESIDUAL IMPACTS

Implementation of the SERP would not result in significant impacts on geology, soils, or paleontological resources; therefore, no mitigation is required, and no significant and unavoidable impacts would occur.